945

NEW TYPES
OF
AMERICAN MOTORS

PREPARED IN THE OFFICE OF
THE DIRECTOR OF AIR SERVICE

AUGUST, 1919

WASHINGTON
GOVERNMENT PRINTING OFFICE
1919

WAR DEPARTMENT
Document No. 945
Office of The Adjutant General

WAR DEPARTMENT,
WASHINGTON, *August 4, 1919.*

The following publication, entitled "New Types of American Motors," is published for the information and guidance of all concerned.

[062.11, A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

PEYTON C. MARCH,
General, Chief of Staff.

OFFICIAL:

P. C. HARRIS,
The Adjutant General.

CONTENTS.

1. The Curtiss K–6 and K–12.

Page.

Gear reduction 7
Ignition 7
Carburetion 7
Lubrication 7
Type of motor 7
Horsepower 8
Bore and stroke 8

2. The Duesenberg Model H.

General data 8
Lubrication 8
Ignition 8
Cooling system 9
Valves 9

3. The Hall-Scott A–8.

4. The King-Bugatti.

General data 10
Ignition 10
Cooling system 10
Lubrication 11

5. The Knox Twelve.

Connecting rods 12
Crankshaft 12
Thrust bearing 12
Crankcase 12
Lubrication 12
Ignition 13

6. The Lawrence 60-Horsepower Air-Cooled Engine.

Cylinders 13
Pistons 13
Crankcase 13
Connecting rods 13
Valve gear 13

7. The Union 6-Cylinder Aeromotor.

Type 14
Power 14
Weight 15

Page.
Cylinders..... 15
Valves..... 15
Rocker arms..... 15
Camshaft housing..... 15
Camshaft gears..... 15
Magneto and pump gears..... 15
Pistons..... 15
Ignition..... 15
Carburetor..... 16
Lubrication..... 16

NEW TYPES OF AMERICAN MOTORS.

1. The Curtiss K–6 and K–12.

In the design of Curtiss K–6 and K–12 motors the form of construction adopted gives a minimum center distance between cylinders, together with careful placing of the accessories, makes the motor compact and easily placed in the fuselage; at the same time the accessibility of the various parts is such that subunit may be readily inspected or overhauled without disturbing the motor in the airplane.

Gear reduction.—The gear reduction of the Model K–12 raises the center of thrust to a point near the center of gravity and close to the center of projected area. This enables the design of the nacelle or fuselage to be reduced in size, with consequent lower head resistant.

Ignition.—Double ignition from the two separate magnetos gives a more instantaneous explosion, which at high engine speed is necessary to develop high mean effective pressures. The spark plugs are located near the intake valves, on the upper side, to guard against fouling and insure absolute ignition. The wire assemblies are inclosed in insulating covers of micarta, which guard against short circuit and injury.

Carburetion.—A duplex carburetor (K–12 is provided with two carburetors), each supplying one set of three cylinders, assures a more satisfactory charge than a single carburetor equipment, due to the separate manifolds which prevent starving and eddying and the better vaporizing properties of two small carburetors over one large one. In addition, hot water jackets are provided on the manifolds to assist in vaporizing the gasoline.

Lubrication.—Pressure feed through crank shaft, propeller shaft, and cam shafts insures a continual film of clean oil on all bearings. Separate return pump with double intake absolutely prevents accumulation of oil in either end of pan, and consequent flooding of cylinders when machine is climbing or gliding. Pressure adjustment permits of individual adequacy of oil feed on each motor, and change for wear and varying conditions of service.

Type of motor.—K–6 is a six-cylinder water-cooled—cylinders en bloc—aluminum construction. K–12 is a 12 cylinder motor with a 5.3 gear reduction to propeller shaft.

Horsepower.—K–6 rated at 150 horsepower at 1,700 revolutions per minute. K–12 rated at 375 horsepower at 2,250 revolutions per minute at crank shaft.

Bore and stroke, 4½ by 6 inches.

	Model K–6.	Model K–12.
	Pounds.	*Pounds.*
Cooling water in motor	.....	38
Basic motor	346	589
Carburetor and intake manifold	18	37
Ignition equipment	32	37
Water inlet lines	4	4
Exhaust manifold	14	28
Hand starting crank	3	.....

2. The Duesenberg Model H.

The Model H, Duesenberg motor, developing 850–900 horsepower, built by the Duesenberg Motor Corporation, of Elizabeth, N. J., is the most ambitious aero engine development that has been attempted in the United States. The motor is of the 16-cylinder V type, with the cylinders at an angle of 45°, and the weight of the power plant with gear drive is 1,575 pounds, without gear drive 1,390 pounds; remarkably low weight ratio for a power plant of its power.

GENERAL DATA.

Number and arrangement of cylinders, 16 V.
Included angle, 45°.
Bore, 6 inches.
Stroke, 7½ inches.
Normal brake horsepower, 800 at 1,800 revolutions per minute.
Type of gear, overhead cam shaft and valve rockers.
Number of carburetors, 4 Miller.

LUBRICATION.

Type, forced feed.
Type of pumps, rotary gear.
Number of pumps, one double pressure and one scavenging.
Ratio of pump speed to crank-shaft speed, 1 to 1.

IGNITION.

Type, battery and generator.
Firing order, L: 4–8–8–2–6–1–5–3–7; R: 1–5–3–7–4–8–2–6.
Type of plug, A. C.
Ratio of generator speed to crank-shaft speed, 2 to 1.

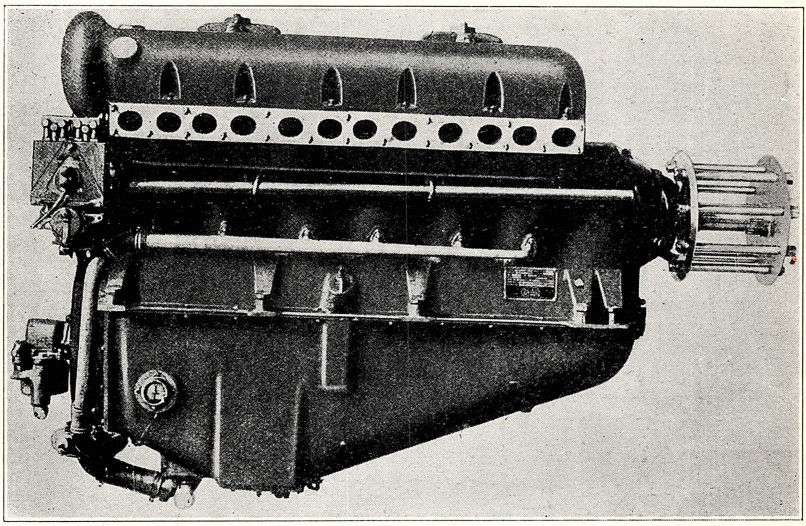

FIG. I.—THE CURTIS MODEL K-12 MOTOR.

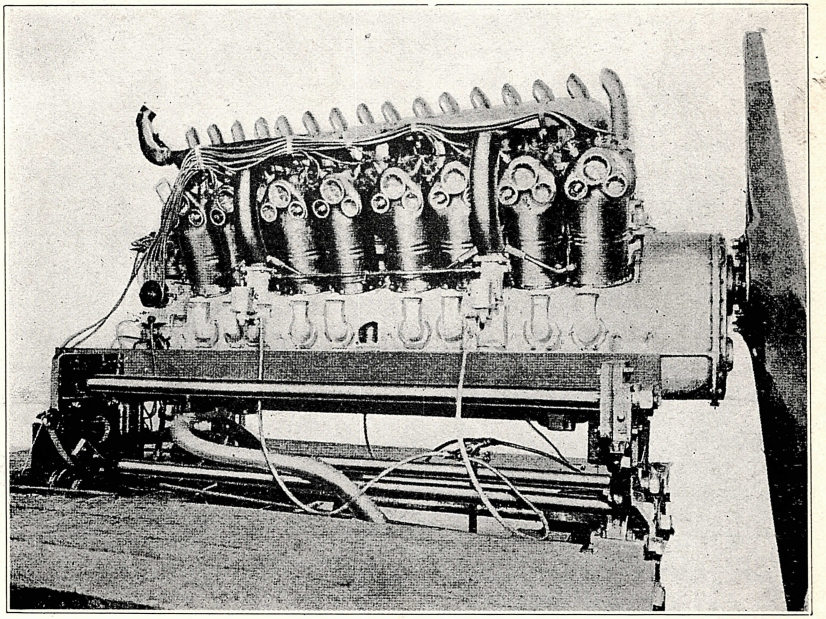

FIG. II.—THE DUESENBERG MODEL H 850-900 HORSEPOWER MOTOR.

FIG. III.—THE HALL-SCOTT MODEL A-8.

COOLING SYSTEM.

Type, water cooled.
Pump, one centrifugal.
Diameter of inlet pipe, $1\frac{5}{8}$ inches.
Diameter of outlet pipe, $1\frac{5}{8}$ inches.
Number of outlets, 2.
Diameter of rotor, $5\frac{3}{4}$ inches.
Ratio of pump speed to crank-shaft speed, 1 to 1.
Water temperature inlet, 125° F.
Water temperature outlet, 155° F.

VALVES.

Number per cylinder, one inlet and two exhaust.
Outside diameter, exhaust $2\frac{3}{16}$ inches, inlet $2\frac{5}{16}$ inches.
Port diameter, exhaust $1\frac{31}{32}$ inches, inlet $2\frac{23}{32}$ inches.
Width of seat, $\frac{7}{64}$ inch.
Angle of seat, 30°.
Valve lift (inlet), $\frac{9}{16}$ inch.

3. The Hall-Scott A-8.

The A-8 is a 12-cylinder engine of advanced design, incorporating many attractive features, and developing a brake horsepower approaching 450, with an engine weight of less than 800 pounds.

The first engine of the A-8 type weighed 1,100 pounds. This was equipped with the cast-iron cylinders, which were made interchangeable with the 4, 6, and 8 cylinder engines of the Hall-Scott design. The company, however, had ready steel cylinders which have been substituted for those in the original engine, and which together with refinements in other parts reduce the total weight, with a built-in electric starter to about 800 pounds or 1.75 pounds per horsepower. Besides the cylinders, many other parts are interchangeable with those of Hall-Scott 4, 6, and 8 cylinder engines of the A-5, A-7, and L-6a types.

The bore and stroke of the A-8 Hall-Scott engine is 5 by 7 inches, the same as in the A-5, A-7, and L-6a types.

The photograph of the new 12-cylinder A-8 engine shows it mounted on the testing block, fitted with the 4-blade propeller, and illustrates very clearly the propeller hub of special Hall-Scott design.

The manufacturers anticipate a similar satisfactory performance in actual service in the A-8 type, as has marked the success of the 4, 6,

and 8 cylinder machines. It is thought that the A–8, designed to meet the peculiar conditions under which American aeroplane engines must function, and to fit the American manufacturing methods, will rank in performance with the better types of foreign engines.

4. The King–Bugatti.

GENERAL DATA.

Number and arrangement of cylinders, 16 vertical, 2 rows of 8 in blocks of 4.
Material, cast iron.
Bore, 4.33 inches 110 mm.
Stroke, 6.3 inches 160 mm.
Stroke-bore ratio, 1.435:1.
Area of one piston, 14.725 square inches.
Total piston area, 235.6 cubic inches.
Swept volume of one cylinder, 92.768 cubic inches.
Displacement of motor, 1,484.288 cubic inches.
Compression ratio, 5:1.
Normal brake horsepower, 410 at 2,000 revolutions per minute.
Type of valve gear, overhead cam shaft and valve rockers.
Number of carburetors, four Miller special.
Ratio propeller to crankshaft speed, 666:1.

IGNITION.

Type, magneto.
Number, 4.
Make, "Dixie 800."
Firing order: 1L, 7R, 5L, 4R, 3L, 8R, 7L, 2R, 4L, 6R, 8L, 1R, 2L, 5R, 6L, 3R.
Number of plugs per cylinder, 2.
Type of plug, Titan A. C.
Advance, 38°.
Magneto rotation, clockwise.

COOLING SYSTEMS.

Type, water cooled.
Pump, 1 centrifugal.
Inside diameter of inlet and outlet elbow to cylinders, 1½ inches.
Number of inlets, 2.
Number of outlets, 2.
Water temperature inlet, 150° F.
Water temperature outlet, 160° F.

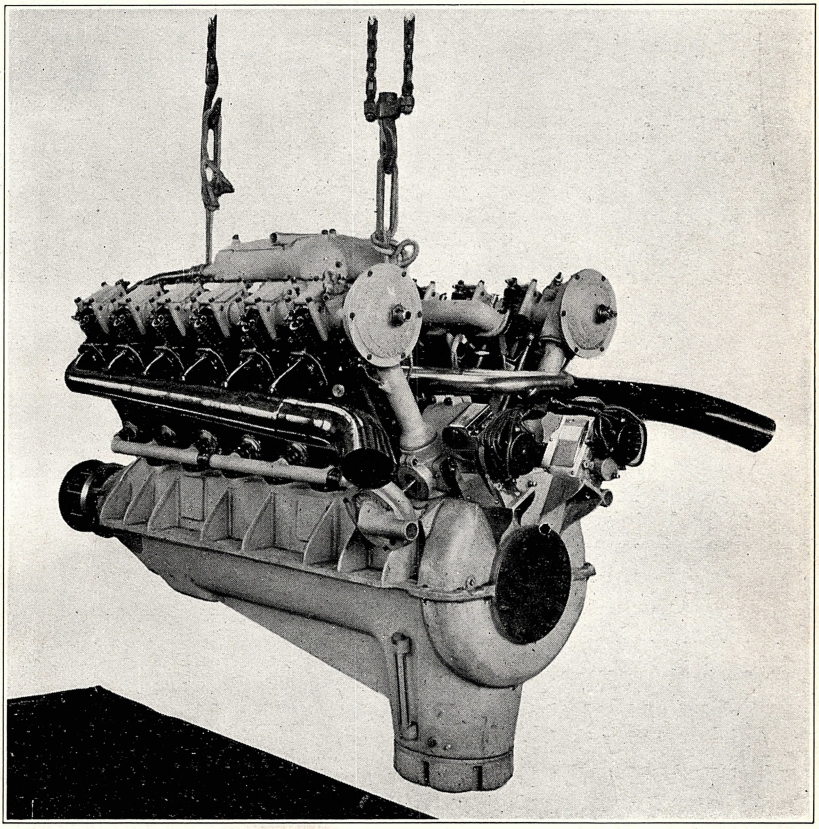

FIG. IV.—THE HALL-SCOTT A-8 12-CYLINDER MOTOR.

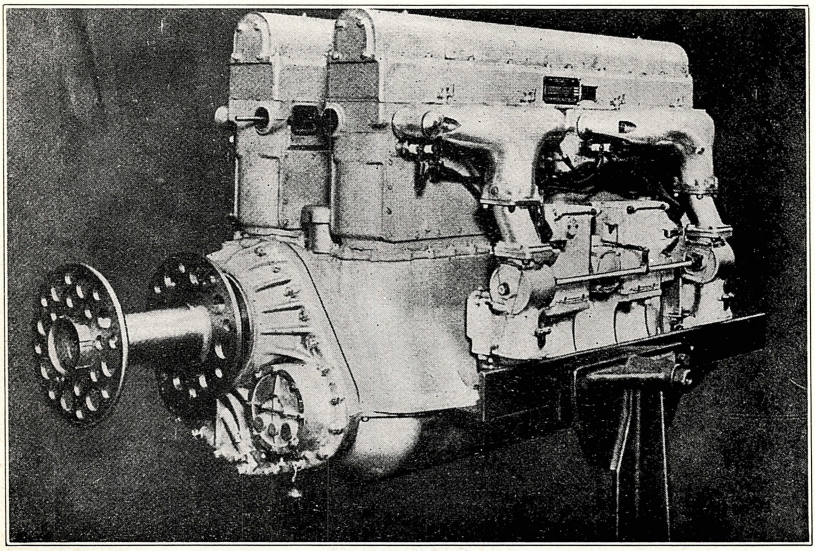

FIG. V.—THE 16-CYLINDER KING-BUGATTI AVIATION MOTOR.

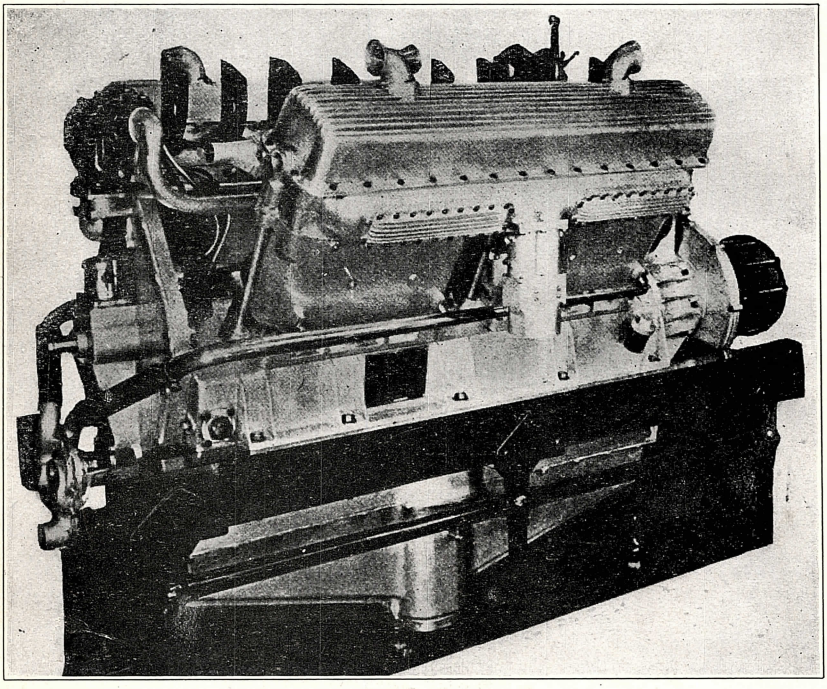

FIG. VI.—THE KNOX TWELVE.

LUBRICATION.

Type, forced feed and spray.
Type of pump, rotary gear.
Number of pumps, one pressure, one scavenging.
Oil pressure, 30 pounds.

5. The Knox Twelve.

When the Knox 300-horsepower aero engine had its first block test in November, 1916, it was then the largest power plant that had been constructed in America. Development of the motor was retarded during the war owing to the other war contracts which the Springfield Motors Co. had.

The original model was a 12-cylinder, 4¾ inches bore by 7 inches stroke and is a V engine with six cylinders on each side, set at 60° from each other.

The crank case is a special aluminum alloy casting in one piece and extending 7 inches below from the center line of the crank shaft to give barrel section for strength.

Instead of using legs for motor supports on the crank case, as is the general practice, this engine is supported by a shelf running the full length of the case on each side of which the motor will rest. Five (5) bolts pass through each shelf into the framework of the aeroplane and a supporting rib or brace is cast each side of each bolt. The motor is very narrow at this point and will enter a frame 15 inches in width inside with bolt centers 17 inches.

The lower half of the crank case is an aluminum casting in one piece and is bolted to the upper half. No mechanism is contained in this lower half and there are no pipe connections to make. A glass gauge is attached to the side of the case, showing the oil level at all times.

The cylinders are special aluminum alloy castings with cast-iron liners ⅛ inch thick. These liners have a flange on the lower end and are pressed in from the bottom. The cylinders are cast in blocks of three and are held to the case by eight studs each. The cylinders are open at both ends and the upper portion of the bore forms the combustion chamber, which is machined all over. The corner bosses are supported by two heavy ribs each and the central bosses run clear through between the cylinders to give strong anchorage. The water jacket extends well down below the bottom of the stroke and ½-inch water space is provided between the cylinders. The piston displacement of the motor is 1,488.53 cubic inches.

The cylinder heads are cast in blocks of six, of special aluminum alloy, and cast-iron valve seats are cast integral with the head. The head for each six cylinders is held down by 16 nickel-steel studs passing clear through the head. There are four valves to each cylinder carried in the cylinder head and the water jacketing is so arranged that each valve seat is practically surrounded by water.

Cam shafts and rocker arms are carried in the head, the cam shafts having eight bearings and the rocker arms being supported above it, as is well illustrated in the photographs.

The cam shafts as well as the rocker arms and all mechanism in the head is under forced feed lubrication and drainage is provided back to the crank case at the center when the motor is in normal position and at each end when the motor is tipped up or down.

Each cylinder head has an aluminum cover which completely conceals and protects all of its mechanism.

Connecting rods.—Connecting rods are I-beam section, of Midvale chrome-nickel steel heat-treated.

Crank shaft.—Crank shaft journals are $2\frac{1}{2}$ inches diameter by $2\frac{1}{2}$ inches long; crank pins are $2\frac{1}{2}$ inches diameter by 3 inches long. In addition to the seven main bearings, there is a bearing just outside of the thrust. Shaft is made of Midvale chrome-nickel steel, heat-treated.

Thrust bearing.—Propeller thrust is taken by a two-way, self-aligning SFK bearing.

Crank case.—Crank case is of aluminum alloy, and in addition to thorough cross-webbing, the side walls are of hollow box section. The stiffness of this construction is so great that the entire propeller torque can be taken through the length of the case without any signs of twisting or vibration, the case during this test being held from rotating at the end opposite to the propeller end only.

Lubrication.—Oil is taken from the crank case by a gear pump, delivered to a combined oil tank and cooler (located where convenient), from which it flows back to a second gear pump which sends it under a pressure of 40 to 90 pounds to the crank shaft journals, through the shaft to the lower rod bearings and up into the piston pin. The holes in the piston for the piston pin being sealed, the oil must pass between the outer surface of the pin and its bearing. From here it is carried to the cylinder walls. The cam shaft, cam-shaft bearings, cams, rocker arms and valve gears are lubricated by oil by-passed from the oil-pressure regulator. This insured force-feed lubrication to all moving parts, even with no oil in the crank case.

Ignition.—Current is furnished by two entirely independent magnetos of either Berling or Dixie make. Each cylinder is fitted with two plugs, each plug being in close contact with water-cooled wall for its entire circumference.

6. The Lawrence 60 Horsepower Air-cooled Engine.

The Lawrence Model L–1 is a 3-cylinder Y-type air-cooled engine rated at 60 horsepower at 1,900 revolutions per minute. The engine delivers 30 horsepower at 800 revolutions per minute and 63 horsepower at 2,100 revolutions per minute.

Bore, 4.25 inches; stroke, 5.25 inches. Cylinder displacement, 225 cubic inches. The weight complete with propeller hub, 130 pounds. This weight includes everything necessary for running, with the exception of the oil tank and mounting plates for which an additional weight of 9 pounds is allowed.

Cylinders.—The cylinders are of cast aluminum with cooling fins machined. Shelby steel liners with walls $\frac{1}{16}$ inch thick are cylinder and the crank case. Liners are casehardened and ground, which gives them a very fine wearing surface. Each cylinder is attached to the crank case by means of six studs.

Pistons.—Pistons are of cast aluminum alloy. Crowns are flat. Each piston has four concentric cast-iron rings and one wiper ring on skirt.

Crank case.—Crank shaft is of chrome-nickel steel. It has a single throw and is counterbalanced. The shaft is hollow for lubrication.

Front end of shaft is tapered to receive the propeller hub which is drawn tight by means of a differential thread nut. The shaft is sturdy and of large dimensions throughout.

Connecting rods.—Connecting rods are of chrome-nickel steel. They are round, of constant section and hollowed for lightness. They are machined all over. Each of the three rods has a segmental shoe which floats in two grooves in the big end bearing. Bearings are of cast bronze with Babbitt lining.

Wrist pins of nickel-steel float in both the rods and pistons. Bronze buttons on the ends of wrist pins keep them from working out sidewise.

Valve gear.—Valve gear consists of three individual camshafts, each with two cams. The push rods are adjustable.

Rocker arms are provided with rollers where they come in contact with the valves so that all side thrust on the valve guides is eliminated.

Valves are of Tungsten steel, $2\frac{1}{16}$ inches in diameter.

Exhaust valves are mercury treated so as to more readily conduct the heat from the head of valve to the stem.

Guides and valve seats are also of cast bronze, set into heads of the aluminum cylinders.

Valve lift (exhaust), $\frac{1}{2}$ inch.

Diameter of stem, inlet $\frac{1}{2}$ inch, exhaust $\frac{7}{16}$ inch.

Length of valve, exhaust $6\frac{27}{32}$ inches, inlet $6\frac{7}{8}$ inches.

Number of springs per valve, two concentric.

Length of springs in position, outer $2\frac{7}{8}$ inches, inner $2\frac{3}{4}$ inches.

Mean diameter of coils (large spring), $1\frac{1}{8}$ inches.

Mean diameter of coils (small spring), 1 inch.

Inlet rocker clearance, 0.010.

Exhaust rocker clearance, 0.015.

CYLINDERS.

Overall height of cylinders, $19\frac{1}{16}$ inches.

Length of projection in crank case, $2\frac{3}{4}$ inches.

Diameter of cylinder over water jacket, $6\frac{27}{32}$ inches minimum.

Diameter of cylinder over water jacket, $7\frac{7}{32}$ inches maximum.

The ignition mountings permit of any standard make magnetos being used and recent motors have been equipped with two 8-cylinder Dixie magnetos of fixed spark and Delco special distributor with battery current furnished by Delco and Liberty generator. The Pilgrim battery ignition system has been tested on this engine also with very successful results.

In the cooling system the water is delivered from the pump through two $1\frac{7}{8}$-inch diameter tubes which connect to two headers or manifolds, one along each side and one located directly under the valves near the top of the cylinders. This header is joined to the cylinder by means of the outlet connections. At each cylinder where the water enters is welded a distributor which leads two streams of water, one directly beneath each exhaust port and a third stream to the outside of the cylinder wall or barrel.

7. The Union 6-cylinder Aeromotor.

The 6-cylinder Union Aeromotor, manufactured by the Union Gas Engine Co., of Oakland, Calif., has many interesting features.

GENERAL DESCRIPTION.

Type.—Six (6) cylinder, vertical, four-cycle, water-cooled, valve in head.

Power.—120 horsepower at 1,350 revolutions per minute.

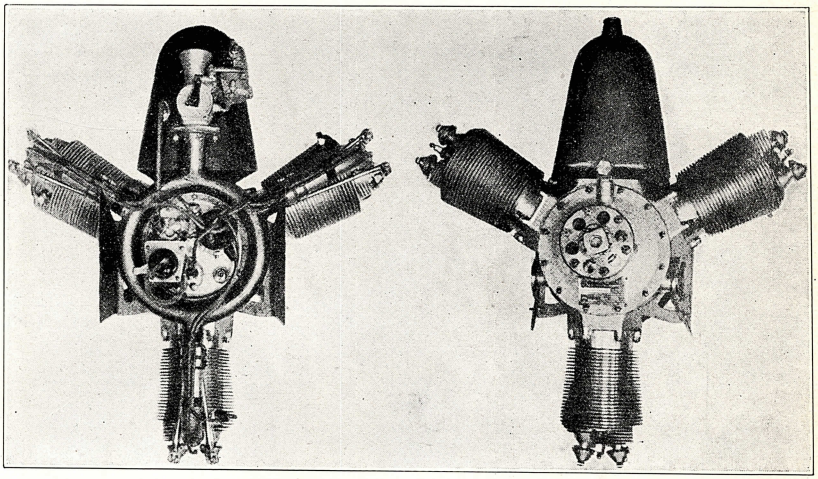

FIG. VII.—THE LAWRANCE 60-HORSEPOWER AIR-COOLED MOTOR.

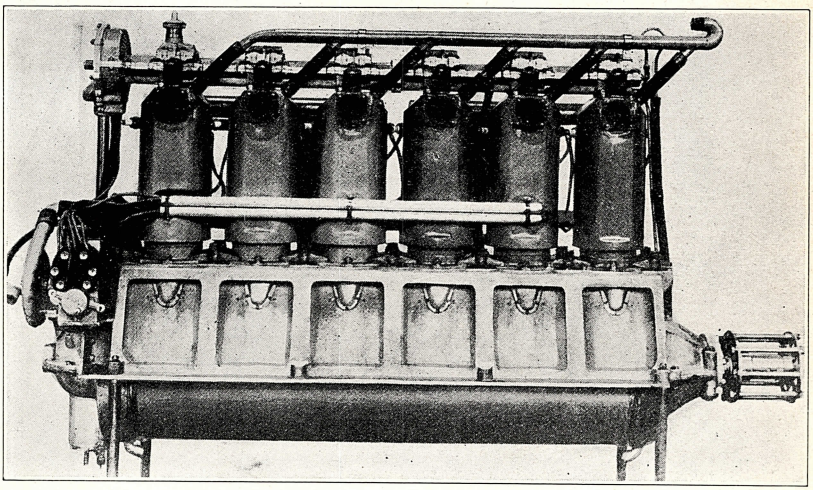

FIG. VIII.—THE UNION 6-CYLINDER AVIATION MOTOR.

Weight.—Engine with two carburetors, two magnetos, pumps, and water piping, weighs 485 pounds.

Cylinders.—Cylinders are of steel, with semisteel head for valves and spark plugs. Base flange integral with walls of cylinder. In test, these cylinders, when held by base flange only, withstood a hydraulic test of over 1,200 pounds per square inch, or a total pressure on the head and base flange of over 10 tons.

Cylinder water jackets are of copper, with brazed joints. Upward thrust of cylinders is taken by chrome-nickel studs extending from main journal caps to cylinder flanges.

Valves.—Valves are of E. W. P. alloy. Stem guide is long, and water-cooled for its entire length. Valve springs are double, concentric, and of the helical type, right and left hand.

Rocker arms.—Rocker arms are machined from solid chrome-nickel steel forgings, and heat treated. Bearings are $\frac{3}{4}$ inch diameter and $2\frac{1}{2}$ inches long. Shape of arms is such that oil leakage is prevented without the use of packing. Excessive wear of valve stem end, caused by point contact of adjusting screw, is eliminated by having line contact in place of points, length of contact between rocker end and valve stem being $\frac{3}{8}$ inch. Valve clearance is obtained by use of small cap with thin disks on end of stem. Cap is held by cotter so that adjustment is positive.

Cam-shaft housing.—Cam-shaft housing is split horizontally along the center line of the cam shaft, permitting easy removal of shaft. To prevent flooding of cam-shaft housing when climbing, a drain from each end of housing leads down to main crank-case pump.

Cam-shaft gears.—All valve gears are of Midvale chrome-nickel steel, heat treated and operate in oil bath.

Magneto and pump gears.—See cam-shaft gears.

Pistons.—Pistons are of Lynnite aluminum alloy. Piston length is 6 inches. Piston pin bearing is $1\frac{1}{4}$ by $2\frac{3}{4}$ inches.

Springs are of a new type. They are conical in shape, wound of flat steel placed edgewise and tapered so that the greater width is in the large coils and lesser width in smaller coils. This permits of a shorter spring than would be possible with the usual helical coil spring.

Ignition.—Two kinds of ignition are supplied. One type is a magneto designed by Mr. Kilsrath, of the Simms Magneto Co., which has a single breaker and one primary winding, but two high tension windings, giving two absolutely synchronized sparks.

Magneto is run $1\frac{1}{2}$ times engine speed. The high tension distributor is separate and driven off one of the crank shafts.

The other ignition system is the "Philbrin," designed by the Philips-Brints Ignition Co. This system has a dual spark with two breakers; either one is used to fire the entire system, allowing perfect synchronization.

Carburetor.—A Miller carburetor is used. It has a throat $1\frac{3}{4}$ inches in diameter.

Lubrication.—Lubrication is by means of pressure supplied by a gear pump. Pressure is maintained at 25 pounds per square inch.

The oil is fed through the rear of crank shaft to the front cover, where it runs to a check valve which maintains the necessary pressure. From this valve the oil drains back to the tank immediately below it. On the front cover plate the by-pass valve operates at a pressure of 50 pounds. It might seem that the two lower cylinders would obtain most of the oil, but, as a matter of fact, it has been proven that the oil is evenly distributed to the three cylinders.

Oil is consumed at the rate of 0.07 pounds per horsepower per hour.